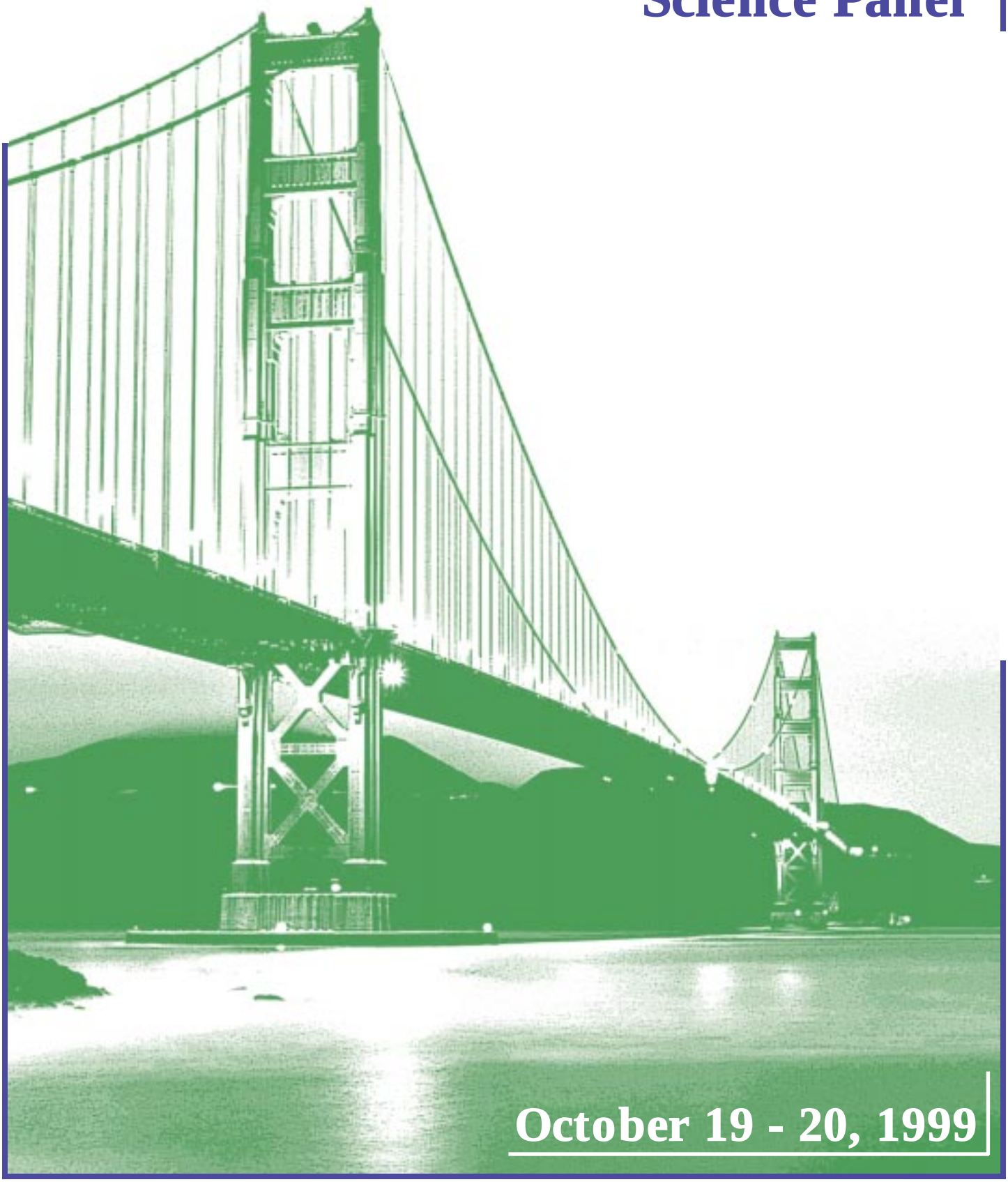
Report of the San Francisco Airport Science Panel



October 19 - 20, 1999

REPORT OF THE SAN FRANCISCO AIRPORT SCIENCE PANEL

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Report of the San Francisco Airport Science Panel

A report from a distinguished panel of scientific experts convened to identify key scientific and environmental questions that should be addressed before airport expansion plans are made.

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Background

New runways have been proposed for both San Francisco and Oakland airports. A new runway at either would result in the largest Bay fill since the modern environmental and coastal resource management framework was established. Few of the state and federal agencies that will play a formal role in permit review or permit issuance have experience in assessing the full effects of projects of this scale.

For the regulatory agencies, the proposed expansions raise complex scientific questions about the potential effects on the Bay and its living resources, both during and after construction, as well as significant policy questions about how best to balance the need for infrastructure to support the Bay-area economy and to protect and restore the Bay's natural resources. Furthermore, projects like the proposed runway expansion at the airports often engender disputes between project advocates and detractors over whether the required environmental reviews address the appropriate scientific questions.

The San Francisco Bay Conservation and Development Commission (BCDC), joined by the other major regulatory agencies in the Bay, requested that the National Oceanic and Atmospheric Administration (NOAA) convene a panel of scientific experts to identify the key scientific questions the airports should address in their environmental reviews. The agencies' purpose in making the request was to ensure that all relevant scientific questions about the projects were raised, and to help minimize conflicts over the perceived quality of the science supporting the airports' permit applications. In response, NOAA formed an interagency working group to develop the panel format, identify initial categories of questions the regulatory agencies believed were relevant to the permit review process, and select independent scientists with expertise in hydrodynamics, sedimentation, water quality, contaminants, and biological resources. Dr. Jerry R. Schubel, President of the New England Aquarium, agreed to chair the panel. Dr. Schubel's full introductory comments are in Appendix A; the names and affiliations of the panelists are listed in Appendix B.

This report summarizes the recommendations of the panel meeting held in San Francisco on October 19-20, 1999.

Opening Statement by Chairman J. R. Schubel on October 20, 1999

The role of the panel is captured in a letter from BCDC to the San Francisco Planning Department and the Federal Aviation Administration (FAA): "As you know, we have asked the National Oceanic and Atmospheric Administration to convene a panel of scientific experts to help frame the questions about this project that need to be answered by the environmental review process." The role of the panel is not to decide whether San Francisco International Airport or Oakland Airport need additional runways, or larger runways, or relocated runways, or even whether additional runways are desirable or justified. Those aren't scientific questions. This is a scientific panel, made up of very distinguished scientists. I have had the honor of working with most of them in the past.

Our role and our goal are to identify and explore the scientific questions that should be included in a comprehensive research program to assess the possible environmental impacts associated with the construction of the proposed runways and following their completion.

As a panel we need to wrestle with the following questions:

- What are the environmental impacts of the proposed design?
- What are the appropriate scientific questions around which to build a research program?
- Do we have enough data and information, and the appropriate numerical models, to answer these questions at acceptable levels of certainty/uncertainty?
- If not, what additional studies would be required? How long would they take?
- The panel also might ask if there are other runway designs which could have smaller environmental impacts and which should be evaluated?

I remind you that the proposed projects at San Francisco and Oakland airports are very significant projects. Either one would be the largest fill project in 30 years in a system that already has had its original surface area reduced by approximately 30% over the past 100 years.

The panel's role is to identify the set of scientific questions that could form the basis for a comprehensive research program to identify and quantify how execution of the proposed projects at the San Francisco (SFO) and Oakland airports would impact the environment's

- living resources
- circulation-motion and mixing of the bay's waters
- sedimentation
- water quality
- values and uses important to society

Setting The Stage

One of the first principles of coastal oceanography is that patterns of motion and mixing of water are strongly influenced by the shape of the sea floor in shallow water bodies such as San Francisco Bay. We know, for example, that the bump on the Bay floor at the San Bruno Shoal plays an important role in influencing currents and tidal mixing, just like the channel constrictions at the San Mateo and Dumbarton Bridges affect the speed and direction of tidal currents. A second principle is that sediment dynamics (that is, rates and patterns of sediment movement, erosion and deposition) are strongly influenced by the motion and mixing of the waters. Thirdly, we know that fundamental aspects of water quality and biological variability also are strongly influenced by the patterns of water circulation and mixing. From long-term study of South San Francisco Bay we know, for example, that the rate of biological production (primary production by phytoplankton) changes rapidly during episodes of reduced vertical mixing of the water. We know too that the concentrations of some contaminants build during the seasons when horizontal mixing is slow and when the residence time of water is long; these contaminants become diluted when the rates of water movement (driven, for example, by events of high Delta outflow) become more rapid.

With these principles in mind, we can say with certainty that a physical structure of the dimensions of the proposed new runways at SFO or the Oakland airport would cause change in the patterns of water circulation and sediment movement/deposition. There is considerable uncertainty, however, in our ability to assess the scale of these changes. Will these changes be confined to only a small region localized to the runway structure(s)? Will they occur on a larger, regional scale adjacent to the airports? Or will these changes propagate to cause changes in the circulation and sediment transport that affect the entire South Bay system (or beyond)? Furthermore, there is uncertainty in our existing ability to assess whether these changes in the physical structure of the Bay, water circulation and sediment transport would cause changes in water quality or biological production and, in turn, alterations to behavior patterns of aquatic organisms (e.g. distribution, recruitment, migration, feeding of invertebrates, fish, and bird species). Therefore, first-order scientific questions are: (1) how will proposed runway structures cause change in Bay hydrodynamics (tidal circulation, mixing, residence time) at a range of spatial scales, from local (few km) to regional (approximately 10 km) to basin-scale; and (2) how will changes in the physical structure, water circulation and mixing, and sediment transport influence water quality and biological processes and communities across this same range of spatial scales?

From a technical perspective, the first question above is the more tractable because we have quantitative principles (rules) that allow us to describe water currents and sediment transport as functions of physical properties such as the shape of the Bay. The second question is more challenging because variability of water quality and biological processes is caused by many features in addition to those associated with water circulation. Assessments of chemical and biological responses to the construction and presence of new runways will, inherently, be more uncertain than assessments of changes in water circulation and, perhaps, sediment transport. Regardless of the magnitude of these uncertainties, there are approaches of study (research, modeling and monitoring) that can be applied to assess the combined physical, geological, chemical and biological responses to these large fill operations.

Setting The Stage (continued)

The most effective approaches of environmental assessment result from a combined application of new measurements (focused to answer specific questions) and the use of numerical models as tools to simulate changes in the physical structure of the Bay and forecast the responses as changes in water circulation and sediment transport. The most effective assessment of the first-order questions will come from an integrated program in which critical new measurements are made, and those new measurements are synthesized with numerical models. Experience has shown that environmental assessments are much less effective when separate programs of field observation and experimentation are conducted independently of model development and simulation. The most timely, cost-effective, and meaningful approach to answer the first-order questions will come from a coherent, integrated program of field observation and measurement and numerical model development and application.

The primary purposes of the new measurement program are: to assess the contemporary condition of water circulation, sediment dynamics, water quality, and value of the Bay habitats to biological communities and populations; to follow changes in these attributes during and following construction of the runway(s); and to fill critical gaps in knowledge required to minimize the uncertainties in our assessments of impact. The primary purposes of the model(s) will be to integrate results of the field measurement program to develop a synthetic picture of how the Bay functions as an ecosystem, and simulate changes in Bay structure and estimate potential impacts on the Bay ecosystem.

GENERAL RECOMMENDATIONS

1. The panel discussed the need for a comprehensive research program. We are unanimous in our conclusion that a peer-reviewed research program is needed. The best scientists and engineers available are needed to conduct this research. All research must exploit the best technologies and focus on the impacts of the proposed expansions. All studies must produce the information needed by decision makers. Success should be measured by the extent to which it reduces uncertainty about the environmental and ecosystem effects of a range of proposed expansion alternatives. While the research program needs to be targeted at the proposed airport projects, it must be a program designed to advance our basic understanding of the natural processes that characterize San Francisco Bay and the human influences on those processes. It also must lead to the development of more powerful diagnostic tools that can be used to evaluate future changes to the system that will occur naturally and as a result of society's decisions.

San Francisco Bay is one of the most highly altered estuarine system in the United States. It also is one of the most valuable to society in terms of its uses. Relative to other estuaries in the United States, the Bay has received relatively little attention in the form of systematic and system-wide research. The panel was relieved to hear a representative of San Francisco International Airport (Lyn Calerdine) state that SFO was committed to a high quality research program and that "we will take as long as it takes to get it right." As data and information are generated, this should be available over the web so that other scientists and interested parties can have access to it. In this way, people can review the approaches and the analyses or conduct their own analyses. Such an approach will increase the transparency of the process–an important quality in the process in which there is such intense interest.

2. If the runways are expanded, we strongly recommend that a carefully crafted, long-term monitoring program be put in place to answer questions or to test hypotheses regarding short- and long-term effects. It could follow the paradigm developed by the National Research Council Committee which produced the report entitled "Managing Troubled Waters."

3. The panel also is unanimous in recommending that the program must be a peer-reviewed process and program at all stages, including the:

- evaluation of proposals and selection of scientists
- evaluation of the conduct of the work
- evaluation of the integration of the various program elements
- evaluation of the end products (reports)

4. The panel recommends that the BCDC, in cooperation with the other Bay management agencies and the research community, take the lead in facilitating the process of identifying and evaluating the various organizational and programmatic models that have been used in managing large, complex, multi-disciplinary environmental research programs whose major goal is to produce information needed by decision makers. From this analysis, a recommendation should be made regarding which model–a model that will be unique in many of its features to San Francisco Bay–is best tuned to the evolving needs and opportunities of the San Francisco Bay estuarine system. The organizational model and the research program clearly must be responsive to the issues raised by the proposed runway expansions, but their utility must not be restricted to these issues. The science must be

Genral Recommendations (continued)

the best fundamental research possible and the model must be flexible enough so that it can be adapted as new issues arise. This requires a combination of sound science and strong leadership and management.

5. It must be emphasized that throughout the research program the "no action" (no runway expansion) alternative needs to be evaluated along with the various runway proposals. Because the Bay is a dynamic, evolving system, it will be important to make projections about:

- how the Bay will evolve naturally
- how the construction of runways could affect that evolution

Some of the answers can be gotten quickly and inexpensively; others will take longer and be more expensive. For adaptive management to work, a program must be put in place to monitor the implementation and effects of the project.

6. This program should be used as an example of adaptive management. Any runway project will extend over a significant number of years and other fill projects will be proposed. This provides an unprecedented opportunity to develop an adaptive management program for the Bay. In adaptive management, advances in knowledge are fed back into the decision making process an on-going basis, and policies and practices are continuously evaluated and revised as appropriate.

7. Finally, we recommend that scientists and engineers be encouraged to search for creative solutions, including designs that fall outside the array of alternatives now on the table for consideration.

SPECIFIC RECOMMENDATIONS

THE IMPORTANCE OF SCALES

Scales of Possible Effectson Physical Processes

We know that circulation in San Francisco Bay is strongly influenced by the bathymetry and by the boundaries. Adding 2-4 mi^2 of fill would alter fundamental physical processes–tidal circulation, residual circulation, waves, sedimentation, mixing (stratification), salinity, and other physical processes.

We must address questions regarding potential physical impacts at a variety of scales in space and time, particularly how those impacts will be manifested in terms of alterations of living resources and beneficial uses.

1. Spatial scales of interest

- very localized scales (mixing length)
- scale of the structures themselves (approximately 2km)
- regional scale (approximately 10km)
- across South San Francisco Bay
- beyond South San Francisco Bay to the entire Bay

The scales of impact and the magnitude of those impacts also will be a function of the locations and geometries of the borrow areas to obtain the fill if those areas are located within the Bay.

2. Temporal scales of interest

- tidal cycle
- seasonal
- annual
- decadal
- longer times scales

MOTION AND MIXING OF THE WATERS

The panel believes one could learn much about the impacts of proposed runway scenarios by exercising the existing numerical models to evaluate both the "no-action" scenario as well proposed runway and borrow area scenarios. Information is needed to determine how the various scenarios affect the circulation, the motion and mixing of the water, and sedimentation at different spatial and temporal scales. Scales of interest include:

- Tidal circulation
- Tidal amplitudes and phasing
- Residual circulation
- Wave field

These modeling efforts should be combined with intensive sampling programs to generate data needed to improve the ability to forecast effects at different scales of time and space and reduce uncertainty. Neither modeling nor field experiments alone can resolve the important questions. Both are needed.

Questions to be Addressed Through Modeling

No-action scenario

Among the questions that need to be addressed in the scenario are:

- How will fresh water discharge be affected by global climate change, increased population, and changing economic pressures, particularly those that will alter the ratio of demands for fresh water among urban, agricultural, and environmental uses?
- How will these changes in the fresh water forcing function affect circulation, mixing and salinity?
- How will the residence time of water (the average length of time a "parcel" of water stays in Bay, or a segment of it) in the Bay as a whole and in its sub-systems be altered?
- How will the annual flush of South San Francisco Bay be affected?
- How will changes in residence time affect contaminant levels?
- What would be the effects on salinity of any projected changes in the quantity or the salinity of waste treatment plant effluent?

Runway expansion scenarios

- How will proposed runway expansion strategies alter sediment budgets and change bathymetry and the mix of habitats?
- What will be the effects of future large mitigation projects (such as initiatives to restore tidal marshes in North Bay and to reclaim salt ponds in South Bay) on flows, flushing, and salinity patterns?
- How will proposed runway development strategies affect tidal amplitude and phases?
- How will proposed runway development strategies affect flood hazards?
- How will the development strategies affect the wind wave environment and wind-driven transport?

Examples of field studies to address physical uncertainties

The panel recommends a field experiment in late winter-early spring which includes intensive salinity and temperature profiles (CTD) and Acoustic Doppler Current Profiler (ADCP) surveys to map the motion, mixing, and structure of the water column during the wet season. Models will have to be adapted or developed to evaluate these effects. The fundamental question being asked in such a field program is: What does South Bay circulation look like during wet seasons? Additional experiments would be required during dry periods and observations eventually will have to be extended long enough to get a good "fix" on seasonal and inter-annual variability of the physical environment under the "no action" scenario. All of these field experiments should be designed to support the numerical modeling needs to address the specific questions raised by the proposed airport runway expansion plans. Knowledge of the wave regime and how it might be impacted by the proposed construction also needs to be improved.

SEDIMENT DYNAMICS

San Francisco Bay is a highly dynamic system in which sediments are alternately suspended and deposited. Over the course of a year, the mass of sediment in motion as a result of alternate resuspension and deposition is far greater than the annual input of new sediment. Human influences on the Bay's sedimentary system have been large and extend back to the gold rush in the Sierra Nevada.

Among the factors that drive and influence the sediment system are:

- Tidal currents (both the speed and direction with which tidal currents move water and sediments)
- Freshwater inflows (which are both sources of sediment and a driving force in determining the estuarine circulation)
- Waves (which provide energy to scour and resuspend bottom sediments and to keep particles in suspension)
- Gravitational circulation (the long-term, net non-tidal circulation driven by salinity gradients which plays a dominant role in controlling sedimentation patterns)
- Sediment inputs (from all sources, including: rivers, shore erosion, non-point sources, biological activity, the sea)
- Sinks for sediment (natural and man-made zones of sediment accumulation)
- Biological processing of the sediments by organisms (including biological processes in the water column which "package" particles into larger units and processes on the bottom that alter the texture and erodibility of bottom sediments)
- Bathymetry (the shape of the seafloor which interacts with the flow field)

The sediment system is, in turn, a major driving force in creating and maintaining the mix of bay habitats. The habitats in turn determine ecosystem character and function.

The development of the proposed runways, with a range of options for execution, represent a new and sizeable influence on the sedimentary regime. The construction options vary in the amounts and configuration of fill and where the spoil would go and the fill would come from. All of these factors will influence the impacts of the project on the Bay's characteristic physical, geological, and biological processes.

Different dredging and disposal scenarios need to be specified and evaluated to assess their effects. A major difficulty in accomplishing this is that forecast uncertainties increase as the time scale of the forecast increases. Predictions of suspended sediment transport at tidal time scales can be accomplished with a high degree of certainty, but predictions of bathymetric change are much less certain. We need to address such questions as:

- What are the contemporary patterns of sedimentation, deposition and erosion in South Bay?
- To what degree could perturbations of the flow regime by the airport protrusion near San Bruno shoals change deposition and erosion patterns of sediments in South Bay? Are these patterns understood well enough to evaluate the impacts of proposed runway expansions?
- Are these patterns understood well enough to evaluate the impacts of proposed runway expansions?
- Can we predict sediment input and export rates, and areas and rates of erosion and deposition?
- Does the configuration of the existing runway still act as an active sediment trap?
- How would different construction scenarios affect the bay-wide sediment budget, and at what scales?
- How would different construction scenarios affect wetlands (erosion of marsh edges, change in marsh elevations, etc.) in different areas of the Bay?

- Will the quantity and quality of sediment available for marsh restoration, and/or sedimentation in harbors, change with changes in water movement, erosion of previously deposited sediments, and sediment transport?

The panel recommends an examination of the area around SFO influenced by existing runways using hydrographic charts and cores to estimate the extent of the shadow area of sedimentation and the rates of sedimentation that is caused by the present runway configuration. Such a study should address the following questions:

- How large is the zone of influence?
- How rapidly did it accumulate sediments?
- Is it still a "sink" for sediments?
- Can we estimate the extent of the zone from which sediments are "drawn" and the locations from which they will be drawn?

The overriding question is:

- What are the sedimentological effects of the proposed projects within the con text of changes that have already taken place and that could take place?

RUNWAY CONSTRUCTION

If there is a runway project, the community needs to be concerned about the environmental impacts during as well as following construction. Determing potential impacts during construction and how those impacts might be controlled and managed are an example. Other examples include:

- How could negative impacts be reduced through selection of fill material and engineering strategies?
- How much sediment is "lost" in the dredging-disposal-fill operations, what are the impacts, and how could the losses be reduced to a minimum?

Borrow Areas

Execution of any of the proposed runway expansion scenarios would require a significant amount of fill material. If the material comes from within the Bay system, where it comes from and the geometry of the borrow areas could have major effects on the sediment system, habitats, and the ecosystem. The effects could range from localized and small to large scale and significant.

- Would proposed runways or borrow areas create large sediment sinks?
- Where will the fill come from? What will be the effects at the borrow sites of different excavation strategies?
- How much sediment is lost during dredging and transport?
- What are the impacts of borrow areas on circulation?

Disposal Areas

If material removed from runway sites is disposed of in the Bay or in ocean waters, there could be physical, water quality, and biological impacts. The LTMS (Long-Term Management Strategy for Dredged Material disposal) has dealt with the issue of dredged material disposal for 10 years. In answering questions about the impacts

at disposal areas and in developing strategies to minimize impacts, the LTMS program should be exploited as a resource. It can be invaluable in assessing impacts and in decision making. We need to ask:

- Where will the dredged material go?
- What will be the effects of different disposal strategies on
  - circulation
  - water quality
  - ecology

Potential Changes in Contaminant Distributions and Effects

Contamination from a number of sources related to the construction of runways represents an important issue that needs to be examined. Potentially important effects of pollutants in water and sediments on biota derive from construction activities, altered flow and sediment transport patterns, and as a result of additional runoff from new impervious areas, including copper from brake linings and jet fuel byproducts. Questions to be addressed include the following:

- Because annual flushing appears to be very important in removing contaminants that build up in South Bay, to what degree would the location of the protrusion of new runways increase the potential for affecting the annual flushing?
- How might the changed circulation patterns uncover the historic contamination legacy or otherwise change the contamination level of the suspended particulate load in South Bay by remobilizing contaminated sediments?
- Will any change in sediment structure near the new runways change the patterns of bioaccumulation of contaminants?
- How will various construction scenarios affect the availability, fate, and effects of contaminants?
- How will changes in water residence time affect contaminant levels?
- How much contamination is mobilized during dredging, disposal, and filling?
- How can the releases be minimized?
- How much of the borrowed sediment for runway construction is contaminated?
- How does the quality of fill material affect leaching rates of contaminants, their sorption onto sediments, their release and resulting impacts?
- To what degree are air emissions from tugs and earth-moving machinery during dredging and disposal a concern?

A variety of sampling programs could be employed to examine contaminants in water, sediments, and biota. Such a program might include analysis of the substrate at the airport and gut content tissue studies of foraging birds, fishes, and invertebrates to assess the intake of contaminants by these animals. An intensive monitoring effort during February-March 2000 should produce an important snapshot of existing conditions, which could be followed by a second period of monitoring in summer 2000. The summer period should coincide with herring spawning and the movement of other important fish through the region and should assess body burdens of contaminants through fish tissue studies.

Environmental toxicology is now focused on chronic, sublethal toxicities. These include the synergistic effects of a suite of toxins and stresses on the most vulnerable life stages of organisms and the most valuable species in a food web or biome.

Examples include reports of sexual dimorphism and dysfunction attributed to xeno-estrogens and of increased disease susceptibility in juvenile salmon exposed to contaminants. It will be important to assess potential for chronic, sublethal toxicities when considering effects of contaminants.

POTENTIAL BIOLOGICAL IMPACTS

It needs to be pointed out that the panel did not have expertise on marine mammals. That deficiency was addressed by having the report reviewed and revised by marine mammal expert Diane Kopec.

Less clear than the potential changes to the physical and sedimentological regimes of San Francisco Bay resulting from airport expansion are those changes that could occur within the biological communities of the Bay. Just because impacts on the physics might be localized, it does not follow that the biological impacts on the ecosystem also will be localized. The areas of impact on physical and biological processes are not necessarily congruent. The following research questions are relevant to all biota.

Some of the important unknowns are the following:

- How might regional or larger scale changes in circulation, turbidity, sedimentation, bathymetry, water quality, and/or contaminant levels, contribute to changes in ecosystem function such as patterns and rates of phytoplankton production?
- Do changes in bathymetry on the west side of the Bay affect uses of that area, as well as the estuary as a whole, by fish and wildlife?
- If there is a change in the mix of habitats, are the changes significant biologically? How would resultant biological alterations be manifested?
- What are the effects on fish and wildlife resources from the disturbance, displacement and release of sediments and contaminants during and following runway construction?
- Eelgrass near the Oakland Airport represents a unique community in San Francisco Bay. How will construction of new runways at Oakland affect present eelgrass beds and the fish and wildlife dependent on them?
- If there are changes in patterns of sediment erosion and accretion or in the tidal amplitude which alter the structure of tidal wetlands and adjacent intertidal mudflats, what are the impacts on the fish and wildlife resources dependent upon these areas?
- What will be the effect on wildlife from increased noise?

In the section below several important and vulnerable animals are identified as well as specific research questions for each species.

Effects on Birds

The proposed construction at SFO would lead to a significant displacement of birds.

- What would be the effects of these displacements on resident and migratory bird populations?
- Because birds tend to have high site fidelity, what is the potential for increased conflicts between birds and airplanes? For instance, will such conflicts affect the endangered least tern?
- Which birds would be favored by the construction and the resulting changes in bathymetry and sediment texture–shorebirds or diving waterfowl?

- How would runway construction alter bird food supply? What would be the effects?
- Is it possible to mitigate loss of shallow, sub-tidal habitat? How? What are the effects?
- Scoter, in particular, are abundant at the airport sites in winter and constitute an important water use. Comparative studies should be carried out to assess the relative importance of these areas to the scoter population.
- How has the loss of habitat affected these species in similar situations elsewhere?
- Will change in sediment structure adjacent to new runways change the foraging potential of the region? It will be important to determine the shift in the benthic community and predict subsequent shifts in food availability and foraging success of scoter and other predators. Converting subtidal areas to intertidal areas as a result of sedimentation could change invertebrate species distributions there from assemblages with larger invertebrates such as large clams to assemblages comprising smaller polychaetes and crustaceans.

Effects on Fish

There is a high diversity of fish on the west side of South Bay. Many forage fish are present and numerous fish (e.g., halibut) are pursued by recreational fishers. Substantial fill in that area of the Bay will take away fish feeding areas and shallow areas used in recreational fishing.

Existing data should be evaluated to assess the importance of the proposed fill areas to important fish species. There is some evidence that embayments of the South Bay serve as saline refugia for a number of species, e.g. northern anchovy. An evaluation should be made of the biological importance of these areas and how the proposed fill projects might affect them.

An early emphasis should be placed on synthesizing and integrating existing data in the context of specific airport questions, including the ones recommended in this report. There are 19 years of fish abundance data on San Francisco Bay. Most of the data concentrates on deeper areas, and there are few data for shallow areas (1-3 meters deep). Sampling should be encouraged in those shallows using small purse seines, small boats, etc. As a start, existing catch information from the proposed fill and adjacent areas should be evaluated. This analysis should be supplemented by shallow water purse seine surveys at several locations on the west side of South Bay, and some additional monitoring should be carried out to assess the relative importance of these areas to the affected population.

From these data, inferences would be drawn regarding the positive and negative effects of the proposed structures and changes in bathymetry and sedimentation. Biological studies should be coupled with the physical and sedimentation studies to assess possible impacts of different construction scenarios.

Some fisheries related questions are the following:

- What are the existing uses of the proposed runway fill areas by herring, surf perch, California halibut, sharks and other species of the area? How would 2-4mi^2 of fill, and the conversion of subtidal areas to intertidal areas as a result of sedimentation, affect their populations?

- What are the patterns of temporal and spatial abundance and community structure in fishes of western South Bay? Larval and young stages have the strongest correlation to currents and salinity.
- What is the recreational fishery in the areas that would be impacted by expansion of the airport runways and how would these areas be impacted under different scenarios?

Questions involving particular fish species are described in the following sections.

Pacific herring and surf perches:
Pacific herring spawn and surf perches parturate (pup) between Candlestick and Coyote Points. Comparative studies should be made to assess the relative importance of these areas to the affected populations. Runways on pilings could benefit some species, but this may be temporary because the area in and around the pilings may fill in. New runways certainly will promote habitat conversion from open water to intertidal mudflats and perhaps marsh. Altering habitats in this way could have some influence on fishing activity in the area.

Salmon and steelhead:
The southern coastal steelhead was recently listed by the National Marine Fisheries Service as an endangered species. Both salmon and steelhead spawn in South Bay creeks. Are steelhead and salmon using the habitats around the airport site? Habitats used by young salmon should be sampled to see whether other areas proposed for fill, and those projected to be subject to sedimentation, are critical to the overall wellbeing of these species in South Bay.

Any sampling program should include the retention of tissue of Chinook salmon smolts to determine races. Winter and spring runs are both listed. DNA samples should be stored for later analysis if needed as we go along.

Effects on Mammals
San Francisco Bay supports a year-round breeding population of harbor seals (Phoca vitulina) and a small non-breeding population of California sea lions (Zalophus californianus). Harbor seals feed primarily within the Bay and depend on specific shoreline haulout sites for pupping and thermoregulation.

Potential impacts from the proposed airport expansions should be viewed in a regional context, which recognizes cumulative issues faced by this population. Organochlorines and trace element residues have been found at toxicologically significant levels in harbor seals sampled in San Francisco Bay. Current construction on the Richmond-San Rafael Bridge may alter harbor seal activity at Castro Rocks, the second largest haulout and pupping site in the Bay, leading to regional changes in seal haulout use patterns.

Questions regarding potential effects on harbor seals should be addressed in the following three areas:

Habitat loss
- Will hydrodynamic changes affect erosion rates of tidal marsh, especially near haulouts on the west side of the South Bay?

- Will mudflat topography be altered in the vicinity of the seven South Bay haulout sites, affecting overall access and the tidal range when the site is available to seals?
- Will runway expansion alter airplane landing patterns over the Bay, increasing noise levels and/or disturbance at the three haulout sites near Redwood Creek and at the haulout on Yerba Buena Island?
- Will on-site runway construction or more distant support activities disturb hauled seals and/or alter pupping activity?
- What effect will any disturbance or haulout site loss have on haulout site use, pup mortality, seal numbers and overall seal activity within the Bay?

Prey Availability

- Will changes in fish recruitment or species composition affect seal prey availability?
- Will seal foraging areas be affected by construction related hydrodynamic changes?
- If prey availability or access is reduced, will it alter seal numbers or activity within the Bay?

Contaminants

- Will toxic residues increase in the Bay's harbor seals and in their prey? What effect will a further increase have on seal health and behavior?

EFFECTS ON SOUTH BAY MARSHES

Changes in the tidal and sedimentation supply regimes could severely affect the form and ecological function of intertidal habitats throughout the sub-region. These effects could result from the placement of fill for runways, the creation of large borrow pits from which fill material is extracted, the restoration of large areas of tidal marsh as mitigation for runway fill, and combinations of these actions. It is important that any analysis of project impacts consider in an integrated fashion the effects of runway fill, borrow pit creation, dredge disposal, and mitigation implementation.

Unfortunately, numerical models do not yet provide simulations at the large spatial and long temporal scales needed to predict the extent to which either or both projects might affect the tidal and sediment supply regimes, especially with regard to tidal marsh form and ecological function. What is required is a combination of efforts to improve numerical modeling of intertidal-bay interactions in South Bay at long temporal and spatial scales, and new studies of past and present rates of change in the distribution and ecological function of the intertidal habitats of South Bay. The model should be calibrated in terms of sediment supply, tidal amplitude, water quality, and tidal prism.

Because existing numerical models cannot forecast the effects of runway projects on tidal and sediment supply regimes for South Bay intertidal habitats, a field program needs to be carried out in combination with new modeling to help quantify the potential impacts. The observational program should address the following:

- What are the existing rates and locations of marsh aggradation and erosion and the associated sediment supply and hydrodynamic regimes?
- What are the salinity patterns in the water column and in the soils?
- What is the present distribution of plant communities?

- What are the patterns of tidal amplitudes in the open bays and within tidal marsh channels large and small?
- What is the present distribution of non-indigenous plant and animal species?
- What is the best forecast of the ecological processes and consequences of non-indigenous species recruitment and population growth?
- Will increased mudflat area around airports be sites for accretion of exotic marsh plants?

This program should be augmented by drawing upon existing data sources useful for assessing spatial patterns of foremarsh erosion and aggradation available through San Francisco Estuary Institute, National Oceanic and Atmospheric Administration (NOAA), the California Coastal Conservancy, State Lands Commission, U.S. Geological Survey, and other organizations.

EFFECTS OF WETLAND MITIGATION

Mitigation strategies should be looked at and evaluated as part of the overall assessment. Mitigation could confound environmental effects of the fill project.

- What are the biological effects of building large number of wetlands in a short period?
- What is the potential for invasive species to become dominant in new wetlands?
- Will there be significant changes in tidal prism as a result of opening large areas of diked baylands to tidal action? If so, what might be the effects?
- How would different mitigation strategies affect residence time of water in South Bay?
- How do mitigation strategies affect sediment dynamics, especially within and adjacent to marshes?
- What are the site-specific impacts of the mitigation measures, such as adjacent levee stability, flood hazards, utility corridor access, charges in mudflat avail ability for shorebirds, recreational uses, etc.?

References

Feynman, Richard P. 1999. Chapter 4, "What is and What Should Be The Role of Scientific Culture in Modern Society"(pp 97-115) in *The Pleasure of Finding Things Out*. Perseus Books, Cambridge MA.

Wolpert, Lewis 1993. *The Unnatural Nature of Science.* Harvard University Press, Cambridge, MA.

Appendix A

Opening Remarks By J. R. Schubel

I would like to outline for you how we will conduct today's proceedings.

First, I will pose a series of questions to the panel. These are questions that scientists and environmental managers believe we need to address. We met yesterday to develop these questions and to sharpen our formulation of them to make today's discussion more informative for you.

After the panel has gone through these and discussed and debated them, I will invite the panel to address questions you may have about the possible impacts of the proposed runways on the San Francisco Bay estuary. If you have questions, you should write them down on one of the 3"x 5" cards available at the back of the room and pass it down to the end of your row. They will be collected periodically, sorted into categories, and handed to me later in the program.

Since this is not a public hearing, we will not accept statements from the floor. There will be other forums in which you can do that. Today you have access to a group of distinguished scientists, and I want to maximize the usefulness to you of that access in helping focus your questions and concerns about the potential impacts of the proposed runway expansions.

We are trying to make the best use of our scientific panel's time and yours. There are advocates for and against this project. We are neither. This discussion can provide you with the information to be better, more informed, and more effective advocates.

If you have not read the latest collection of essays and talks entitled *The Pleasure of Finding Things Out* by the late Richard Feynman, I recommend it to you. Feynman points out in the essay called "What is and What Should be the Role of Scientific Culture in Modern Society" that "You are able to do things after you know something scientifically. But the science does not give instructions with this power as to how to do good against how to do evil. Let us put it a very simple way: there are no instructions along with the power, and the question of applying the science or not is essentially the problem of organizing the applications in a way that doesn't do too much harm and does as much good as possible" (Feynman 1999). In other words, science doesn't come with instructions on how to apply it.

As Lewis Wolpert observed in The Unnatural Nature of Science, "it would be a great folly to entrust decisions about how to use science to scientists or to any other group of experts. It is the politicians, lawyers, philosophers and finally all citizens who have to decide what sort of society we will live in" (Wolpert 1993). Tolstoy once said: "Science doesn't tell us how to live. It has nothing to contribute on moral grounds." Both Wolpert and Tolstoy were correct.

While science is never "value free" because it is done by individuals, all of whom have values, by bringing groups of distinguished scientists together one can try to achieve "consensus" and "smooth out" the individual scientist's values. That is our goal.

Let's come back to the airports.

Science can tell us with some level of certainty what the environmental impacts of construction of runways would be on the Bay during construction and after construction is complete. Whether or not those impacts are acceptable is a societal decision, not a scientific one. Science also can tell us which airport runway designs or construction strategies minimize adverse environmental impacts.

Knowing the impacts should help society make a decision consistent with the uses and values of San Francisco Bay that are important to society.

I recommend that those of you in the audience consider that you are listening in on a conversation of a group of distinguished scientists who are discussing how to assess the environmental impacts of the proposed expansion of San Francisco and Oakland airports, and that you have an opportunity to inject into that discussion your questions.

At the end, I will try to summarize the proceedings.

I hope we can spend most of our time on the issues/questions that are important and "uncertain." Of course, in nature and in science, there is no such thing as absolute certainty. That is why scientists-good scientists-have the irritating habit of always adding qualifiers. It's all a matter of degree, but you get the idea; uncertain corresponds to falling outside the "acceptable" bounds of certainty and associated risk--outside the comfort zone.

If it's important but "certain," we will try to deal with it quickly and decisively. If it's unimportant and either "certain," or "uncertain," let's also try to deal with it swiftly and decisively. We want to concentrate on the important and "uncertain" issues and figure out what it will take to reduce the level of uncertainty to acceptable levels. We may be able to do that with existing data and information, or it might take carefully designed studies targeted to a set of specific questions.

Before we begin the panel's discussion we will have a brief description of the proposed San Francisco International Airport runway expansion by Lyn Calerdine (Environmental Manager, Airfield Development Bureau, San Francisco International Airport) and an even briefer description of the Oakland Airport's proposed expansion by Kristi McKenney (Aviation Planner, Oakland International Airport).

Following the presentations, I will ask the panelists if they have any questions to clarify any aspects of the proposals. Next, I will address my questions to the panel. Following that, I will address your questions to the panel. Finally, I will summarize and perhaps offer some suggestions for next steps.

I am your moderator. A moderator is defined in "The Devil's Dictionary "as "one who finds reason among widely divergent views." I will leave it to you if I am successful in finding reason.

Appendix B

Science Panel on Runways in San Francisco Bay Chair

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